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Measuring Anxiety Towards Wiki Editing: Investigating the Dimensionality of the Wiki Anxiety Inventory-Editing

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Although wikis are common in both the workplace and in Higher Education, little research has studied the wiki user experience. Recent literature highlights that users may be anxious about editing wiki content; yet in most of this research this anxiety has not been measured quantitatively. Although computer anxiety metrics exist to measure anxiety towards technology, they lack specificity and relevance to the wiki editing context. This paper reports two studies used to research the validity and reliability of the wiki anxiety inventory-editing (WAI-E), an inventory developed and used to measure anxiety in wiki editing (Study 1) and to explore the factor structure of the WAI-E and the validity and reliability of the resulting subscales (Study 2). Study 1 shows that the WAI-E, when used as a uni-dimensional structure, shows high reliability and validity. The principal component analysis conducted in Study 2 showed that the measure converged on a three-factor solution with factors measuring positive affect, editability anxiety and contribution judgement anxiety. The subscales showed high reliability and validity. It therefore seems that although the validity and reliability of using the WAI-E as a uni-dimensional construct are high, the use of the metric as such hides the true structure and nuances of the concept of wiki anxiety.

RESEARCH HIGHLIGHTS

- The paper presents a self-report inventory (wiki anxiety inventory-editing, WAI-E) to measure anxiety in wiki editing.
- The uni-dimensional WAI-E has good reliability and validity.
- Principal component analysis (PCA) highlights three factors: positive affect, editability anxiety and contribution judgement anxiety.
- These factors also show high reliability and validity.
- PCA shows that use of uni-dimensional WAI-E masks strong factor structure of WAI-E.

Keywords: collaborative content creation, collaborative and social computing design and evaluation, HCI design and evaluation methods, empirical studies in HCI, blogs, wikis & Similar, empirical studies in collaborative and social computing

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1. INTRODUCTION

The benefits of using wikis as collaborative tools for knowledge sharing and co-creation such as their facilitation of democratic knowledge construction (Glaser, 2004), their dynamic nature leading to highly up to date knowledge and their ability to allow consumers of knowledge to become co-creators (Mader, 2008; Ravid *et al.*, 2008) have been well documented in the wiki literature. Their use in both educational and business contexts has also become commonplace. However, very little work has studied and attempted to quantify variables related to the wiki user experience, specifically how users feel towards wiki editing (Liu, 2009; Ramanau and Geng, 2009). This understanding is necessary as wikis become more common in a variety of realms such as Higher Education and the wider economy. To further the scientific understanding of the wiki user experience, there is a need for research to develop metrics to measure concepts relevant to this experience. This quantification will facilitate the study of the correlates, predictors and causal influences of wiki site characteristics on such variables.

Recent wiki literature has eluded to users being anxious over editing wiki content (Giordano, 2007; Guzdial *et al.*, 2001; Liu, 2009; Lund and Smordal, 2006—a wider discussion of this literature is included below) with research also looking at how aspects of the interaction impact on anxiety towards wiki editing (Cowan and Jack, 2010, 2011). Previous research on IT anxieties has shown that negative emotions towards interaction can result in significant negative cognitive consequences, leading users to off-task thinking and cognitive avoidance (Smith and Caputi, 2001, 2007). If wiki use is expected or made a compulsory part of a course or enterprise's information-sharing processes, this anxiety may lead users to edit in distress, may impact the user cognitively, thus affecting task performance, and indeed may minimize their participation in wiki sites. As early research on computer-supported co-operative work highlights, full user engagement and commitment is needed for such collaborative systems to succeed (Ehrlich, 1987; Grudin, 1988). If users experience anxiety when editing, they are unlikely to commit to using the system frequently, a conclusion supported by the impact of computer anxiety on computer avoidance (Chua *et al.*, 1999; Weil and Rosen, 1995), and the system may fail as a result. First experiences with technology that are free of anxiety, in that they are fun, relaxed and the user feels in control, are important to users gaining further experience with technology (Beckers and Schmidt, 2003). As stated by Grudin (1988), we need to '. . .know more about the individual differences in responding to technology if we are to develop systems that can support entire groups' (p. 90). It is therefore imperative that we research the causes, nature and impact of individuals' anxiety as this may play a crucial part in wiki success and participation. Developing a measure of wiki anxiety is a critical part of facilitating such research.

Although studies have been conducted looking at wiki use in a variety of scenarios, very little research has been conducted looking at the user experience of wiki interactions. Recent research has suggested that users may hold anxious feelings when editing wikis, yet very few studies have attempted to measure this quantitatively. Qualitative research of wiki use in enterprise (Holtzblatt *et al.*, 2010) and of a Higher Education tool Co-Web (Guzdial *et al.*, 2002), which operates similarly to a wiki, highlights that contributors can be anxious that their contributions will be judged unfavourably by other site users. A similar user posting anxiety due to audience concerns was also noted in research on blogs (Liu, 2010) as well as wikis (Liu, 2009), with the social nature of content creation formation and presentation on these sites being hypothesized as a potential stressor. Indeed, this has been highlighted in other social technology research, whereby users fear that they may make their misinterpretations and lack of knowledge public to other users by contributing content to social systems (Orlikowski, 1992). Additionally the openness, flexibility and editability of wiki content may also be a concern for editors. Users have expressed anxiety at the fact that their edits can be amended and deleted (Raitman *et al.*, 2005) without being informed of a reason (Glaser, 2004). Users have stated concerns that 'someone can change what you have written, even when you know what you have written is correct' (Lund and Smordal, 2006, p. 41). Research on collaborative writing also found that people would not change others' content due to a concern for hurting the feelings of other group members (Kim and Eklundh, 2001). This concern over the fluidity and lack of control of the state of information on such systems has also been documented in research on groupware in organizations (Orlikowski, 1992).

The concept of anxiety towards technologies, although highly relevant to the user experience domain, is not a new one. Over 20 years of research has shown that a significant percentage find technology interactions a source of anxiety and discomfort (Farina *et al.*, 1991; Heinssen *et al.*, 1987; Joiner *et al.*, 2007; McIlroy *et al.*, 2007) with most research on anxiety towards IT focusing on the two concepts of computer anxiety and Internet anxiety. Recent research has shown that even experienced users of computer systems can hold an amount of anxious feelings towards computers (Beckers *et al.*, 2006). Anxiety towards IT interactions is therefore a significant concern and an emotion that needs considerable attention within the user experience community.

Through the research on computer anxiety specifically, a plethora of measures have been developed to measure anxiety towards computer use (CARS (Heinssen *et al.*, 1987); BSCAS (Beckers *et al.*, 2007); Computer Attitude Scale (Nickell and Pinto, 1986), although this list is not exhaustive) and Internet interactions (Joiner *et al.*, 2007; Thatcher *et al.*, 2007). Yet, if we apply these to 21st Century computer user experiences (such as in the context of wiki use), the metrics lack specificity and item relevance to potential stressors in 21st Century computer interactions, making them unsuitable to accurately measure the anxiety people experience in more modern technological

interactions. The advent of Web 2.0 has seen a shift in how users interact and behave with computer technologies, using technology to create content and interact in an online social space. More specific to the measurement of negative emotions during wiki use, the development of Web 2.0 has seen mainstream computer use transformed to include collaborative systems and tasks. The concepts of Internet and computer anxiety are inadequate for the measurement of negative emotion towards Web 2.0 applications as they focus on a general anxiety towards computers and do not include reference to the social, dynamic and collaborative nature of this development in computing.

Additionally such measures focus on a generic stressor impacting their sensitivity to measure anxiety towards a specific stressor. Measures of computer anxiety make it very hard to measure specifically what is the stressor within the interaction for users. The use of a computer is a complex activity involving interactions with hardware, software and a variety of interfaces. Owing to this the use of such an overarching concept is inappropriate if we are to encapsulate and observe anxiety related to wikis, and indeed other specific computer uses, effectively. Computer anxiety may form part of the stress induced (although recent research suggests that computer anxiety does not effectively reflect the anxiety experienced when wiki editing (Cowan and Jack, 2011)), yet the wiki literature discussed suggests there are social concerns of judgement and accuracy of contribution as well as concerns over editability that need to be represented in an effective measure of anxiety experienced with wiki technology.

Specifically through research looking at how wiki site characteristics impact on anxiety (Cowan and Jack 2010, 2011, 2014), a questionnaire has been developed to measure users' anxiety when wiki editing (Wiki Anxiety Inventory-Editing: WAI-E). These studies present a measure by which anxiety experienced when wiki editing can be quantified and thus can be measured and monitored in research investigating the phenomenon. This paper discusses the creation of the metric and aims to explore the validity and reliability of the WAI-E when used as a uni-dimensional metric, as used in previous research (Cowan and Jack 2010, 2014). We also aim to explore the potential factor structure and the reliability and validity of subscales resulting from an exploratory factor analysis of the metric.

Before discussing the development of such a metric, we must first be clear as to what a wiki is. A wiki is a website that is fully editable by a user community. Users can view, add and alter the structure of content on a wiki site. The ability to contribute content and wiki editability allows for knowledge to accrue through group collaboration with mistakes or conceptual falsehoods being amended and/or removed as the users see fit (Wang and Turner, 2004). The concept gained prominence with the creation of the online encyclopedia *Wikipedia* in 2001, a collaboratively created online knowledge resource (Bryant *et al.*, 2005). At their core, wikis operate on the principle of incremental free form content formation through open editing, relieving users of any structural and publishing permission constraints when authoring content (Desilets *et al.*, 2005; Glaser, 2004). In their purest form the pages on these sites have no predefined structure (Jaksch *et al.*, 2008) with anyone being able to create and modify content and pages (Wang and Turner, 2004). This ethos ideally leads to a democratic socially created knowledge resource where all users are equal in their rights to both edit and read wiki content (Glaser, 2004). In reality many wiki sites impose access barriers such as user logins making sure only select users can access and are allowed to edit site content. In many cases, all pages that can be viewed are editable by users, although this is dependent on user permissions. Their editability means that wiki content is in a perpetual state of flux. Content can be updated, changed and improved by users (Di Iorio and Zacchiroli, 2006), which leads to making a highly current knowledge resource (Mader, 2008; Ravid *et al.*, 2008).

All wikis operate in two states: a read state and an edit state (Augar *et al.*, 2004). User interaction in the read state leads a user to access and view content that has been included on the wiki by wiki editors. In the edit state users are able to edit wiki content. Through an editing interface (either Wiki Markup Editor or Rich Text WYSIWYG editor) users are free to add, delete and change content, structure and navigational elements on the wiki. Upon saving these changes, they then become viewable in the read state. A page history is also created that records the edits conducted, editor information and other related data (Mader, 2008).

This paper describes the development of the WAI-E (Cowan and Jack 2010, 2014), a psychometric developed to measure the anxiety people experience towards wiki editing. We aim to demonstrate the validity and reliability of its use as a uni-dimensional measure (Study 1) as well as exploring the factor structure of the metric and the validity and reliability of the measure subscales (Study 2). In both studies, to assess the validity of the use of the uni-dimensional metric and the subscales we measured participants on dimensions such as fear of negative evaluation, trait and state anxiety. Correlation with these variables will not only allow us to infer the validity of the metric and subscales but would indicate the psychometric properties of the WAI-E in terms of its anxiety construct. State anxiety is seen as temporary and more situation based than trait anxiety, which measures a deep-seated predisposition to be anxious in potentially stressful situations (Beckers *et al.*, 2007; Endler, 2001; Leso and Peck, 1992). Relationships with these anxiety variables allow us to infer whether wiki anxiety is associated with a situational or deeper-seated anxiety concept. Study 2 looks to test the assumption of uni-dimensionality of the scale by conducting an exploratory factor analysis on the WAI-E and demonstrate factor validity through correlation with the pre-mentioned concepts. We hypothesize that although the uni-dimensional scale will show high reliability and good validity, the metric will show a stable factor structure.

2. DEVELOPING THE WAI-E

2.1. Item development

When creating the items, a collection of anxiety related words were gathered from state and trait anxiety measures (Marteau and Bekker, 1992; Spielberger *et al.*, 1983) and other anxiety measures not relevant to IT such as the Test Anxiety Inventory (Taylor and Deane, 2002) to ensure accurate reflection of the emotion of anxiety. A pool of 60 items was then generated from themes and items from computer anxiety questionnaires and computer anxiety items in computer attitude questionnaires (Barbeite and Weiss, 2004; Garland and Noyes, 2008; Heinssen *et al.*, 1987; Nickell and Pinto, 1986; Venkatesh, 2000) as well as from measures of fear of negative evaluation (Weeks *et al.*, 2005) due to the wiki's social core. Items in this pool were also created from insight gathered from informal discussions and interviews with four wiki co-ordinators at the University of Edinburgh as well as the previous literature discussed above on wiki use. The co-ordinators included academics with experience using wikis in undergraduate course teaching as well as members of the central wiki service support team at the University. It was from these discussions and the literature on the openness, flexibility and social aspects of wiki editing that item themes focusing on wikis' social and flexible nature were included. A wiki is completely modifiable in its content, structure and layout. As suggested in research mentioned previously (Lund and Smordal, 2006; Orlikowski, 1992; Raitman *et al.*, 2005), users may therefore not only be anxious about the fact that they can accidentally change content but that the content itself can be changed and thus the content they add may be amended. All such aspects lead to uncertainty in the permanence of information. Negative evaluation by others may also be of concern when users edit a wiki. Students may feel anxious about editing content for fear of their edits being judged by other users on the accuracy and quality of the edits made, as highlighted by previous work (Guzdial *et al.*, 2002; Holtzblatt *et al.*, 2010; Orlikowski, 1992). Both these aspects are therefore important to the concept of wiki anxiety in an editing context and thus items were created reflecting these concepts.

These 60 initial items were created and then reviewed by a panel of 5 experts. These experts were University staff with expertise in HCI and usability engineering, wiki technology use and questionnaire design. From this process, the number of items was reduced by 25 to 35 items. The main reasons for excluding items from the set of 60 were the panel judging the items to have (i) low relevance to a wiki-editing scenario and (ii) conceptually having adequate coverage in other stronger items in the 60-item pool. A further round of review brought changes and additions to these items in improving the clarity of concepts and wording in the 35 items kept, bringing the item total to 39. These 39 items were then administered to a small group of 8 participants who were asked to take part in a small pilot study aiming to examine the quality of the items gathered. Participants were asked to edit a wiki page and were asked to assess the item wording and concept clarity of each of the items in the anxiety measure. This aided the process of identifying items that needed further development, rewording or item removal at a final panel meeting. A final shortlist of 22 items was agreed upon in a further meeting of a panel of 5 experts with expertise in usability engineering, wiki use and HCI questionnaire design. Those items that were removed from the 39 items were removed because they were seen by the panel as (i) being attitude statements rather than focusing on the emotional concept of anxiety and (ii) their concepts were more clearly covered in other stronger items. This process led to a final version of the WAI-E, the one administered to participants in the studies presented. The WAI-E administered is included in Appendix A.

3. STUDY 1

3.1. Method

3.1.1. Sample

Fifty participants (38 F, 12 M) from the University of Edinburgh community completed the questionnaires in the study when taking part in an experiment looking at wiki editing. The sample was recruited using volunteer sampling, with participants being asked to volunteer to take part in return for an honorarium through an email advertisement. The mean age of the sample is 21.96 years (SD = 3.31 years). As part of the requirements for the experiment, participants had edited a wiki before.

3.1.2. Metrics

Metrics included in the research to analyse the validity of the WAI-E included state anxiety (Marteau and Bekker, 1992), trait anxiety (Spielberger *et al.*, 1983) and fear of negative evaluation (Collins *et al.*, 2005).

State anxiety. State anxiety was measured using the short version of the state section of the State Trait anxiety Inventory (Marteau and Bekker, 1992). State anxiety is defined in the literature as 'a transitory emotional reaction that is characterized by subjective, perceived feelings of apprehension, tension and worry whose intensity varies over time' (Li and Lopez, 2005, p. 1084). The measure includes six items (three negative and three positive) referring to people's anxiety at the moment of measurement. The metric uses a four-point Likert scale ranging from 'Not at all' (1) to 'Very Much' (4). Positive items were reverse scored so that the total score reflected anxiety.

Trait anxiety. Trait anxiety was measured using the trait section of the State Trait Anxiety Inventory (Spielberger *et al.*, 1983). Trait anxiety is conceptualized as a measurement of '. . .individual differences in general proneness to anxiety' (Li and Lopez, 2005, p. 1084). The questionnaire has 20 items (9 positive items and 11 negative). Participants were asked to respond to the items thinking about how they *generally* feel. Trait anxiety was measured using a four-point Likert scale ranging from 'Almost Never' (1) to 'Almost Always' (4). Positively worded items were reverse scored so that the total score reflected anxiety.

Fear of negative evaluation. The brief version of the fear of negative evaluation (FNEB) scale (Collins *et al.*, 2005) contains 12 negatively worded items measuring people's discomfort and apprehension about social evaluation. It was measured using a five-point Likert scale ranging from 'Strongly Disagree' (1) to 'Strongly Agree' (5). Previous research has highlighted the poor validity of positively worded items included in previous versions of this scale, stating that participants find the interpretation of these difficult (Carleton *et al.*, 2006; Duke *et al.*, 2006; Weeks *et al.*, 2005). Previous studies have therefore recommended the use of negatively worded versions of these positive items, making a wholly negative itemed scale, to preserve scale sensitivity (Carleton *et al.*, 2006; Collins *et al.*, 2005). Therefore, no reverse scoring was necessary in calculating the total score of the scale.

3.1.3. *Procedure*

The data analysed in Study 1 were collected as part of the experiment presented in Cowan and Jack (2014). Participants were recruited via email and were asked to take part in research investigating web-based learning tools. Upon arrival at the laboratory participants were welcomed by the experimenter and were told that they were to contribute information to a wiki. The experimenter completed a demographic questionnaire with the participant, asking questions about previous courses taken, gender, age and experience with wikis. After completing the demographic questionnaire participants completed the trait anxiety (Trait) and FNEB scales.

Participants were then asked to edit content on the wiki. Participants were given an excerpt that they were to contribute to the wiki. They were asked to take as long as they needed to read the excerpt and use the information from the excerpt to complete the tasks of contributing to the wiki during the experiment in their own words. After completing their edit, participants were asked to complete state anxiety (State-E) and wiki anxiety (WAI-E) questionnaires. Upon completing the experiment, participants were thanked for participation and given an £8 honorarium for taking part.

3.2. Results

3.2.1. *Internal consistency reliability*

All scales used in the study showed high internal reliability (Trait: $\alpha = 0.90$; FNEB: $\alpha = 0.90$; State-E: $\alpha = 0.88$; WAI-E: $\alpha = 0.93$). As can be seen, the WAI-E has high internal consistency scores, higher than the 0.7 criterion for good psychometric reliability (Kline, 2000).

3.2.2. *Test–retest reliability*

Participants in the sample from Study 1 (Time 1) were tested again on the measures 4 months (Time 2) from the previous administration of the questionnaires. The measure at Time 2 was measured 4 months after as part of a later experiment. The experiment used the same design as the experiment layout in the method section above. The mean and standard deviation of the metrics at Time 1 and Time 2 are included in Table 1. The results show that the WAI-E measure has high test–retest reliability as a uni-dimensional construct. Strong and significant correlations existed between Time 1 and Time 2 scores on the WAI-E scale [$r(48) = 0.77$, $P < 0.001$)]. The correlation coefficient obtained is higher than the minimum acceptable coefficient for test–retest reliability (Kline, 2000).

Table 1. Descriptive statistics for correlation variables.

	State anxiety	Trait anxiety	FNEB	WAI-E (Time 1)	WAI-E (Time 2)
N	50	50	50	50	50
Number of items	6	20	12	22	22
Mean	12.38	38.94	36.91	59.66	54.84
SD	3.67	8.72	10.06	16.44	16.29
Scale	6–24	20–80	12–60	22–110	22–110
Min	6	24	19	27	24
Max	20	60	54	91	94

3.2.3. *Validity*

To determine the scale's validity, Pearson's correlations were performed to identify how total WAI-E scores correlated with the other questionnaires included in the research at Time 1. The means and standard deviations of each measure are displayed in Table 1.

WAI-E scores correlated significantly and strongly with state anxiety measured directly after wiki editing [$r(48) = 0.73$, $P < 0.001$] as well as with fear of negative evaluation [$r(48) = 0.42$, $P = 0.002$]. It, however, did not correlate significantly with trait anxiety [$r(48) = 0.27$, $P = 0.06$], suggesting that the anxiety measured is more state than trait based.

From the findings presented all measures used in the study had high internal reliability. The WAI-E scale as a uni-dimensional scale showed high levels of internal reliability and test–retest reliability for a psychometric (Kline, 2000). The construct validity of the uni-dimensional version of the WAI-E was also high. Our findings show that participants' wiki anxiety scores correlated significantly and positively with fear of negative evaluation and state anxiety. The wiki anxiety scale therefore seems to reflect a social anxiety that users may hold during editing on such a social system.

The findings above suggest that using such a measure uni-dimensionally (as in Cowan and Jack, 2010, 2014) shows validity in that the measure correlates significantly with both fear of negative evaluation anxiety and state anxiety. The metric also shows high internal and test–retest reliability when used in this context. Although this measure has shown good validity and reliability as a uni-dimensional scale, the use of the measure as such may mask the true dimensionality of the measure. As such we conducted an exploratory factor analysis to explore the factor structure of the measure. As the measure was created using items reflecting anxiety towards aspects such as social

judgement, flexibility and editability concerns as well as general items towards editing, we would expect the scale to be multi-dimensional. The next study presents a principal component analysis (PCA) of the measure to identify the dimensions within the questionnaire developed whilst exploring the reliability and validity of the subscales. PCA was used because of its lack of need for an *a priori* hypothesized structure, making it highly applicable for factor exploration in initial scale development and evaluation (Bryant and Yarnold, 1995; Hurley *et al.*, 1997). More exploratory analyses such as PCA do not depend on a specified factor structure (in comparison with confirmatory factor analysis which does), allowing item loadings on non-hypothesized factors (Hurley *et al.*, 1997). As highlighted by Kline (2000), a minimum of 100 participants are needed for such an analysis to ensure that error in the correlation matrix does not impact on the analysis validity with a participant item ratio of 2:1 being adequate if the data hold a clear factor structure.

4. STUDY 2

4.1. Method

4.1.1. Sample

A total of 124 (45 M, 79 F) participants completed the WAI-E when taking part in an experiment looking at wiki editing. Again the sample was recruited using volunteer sampling, whereby students were asked to take part in return for an honorarium through an email advertisement. The mean age of the sample was 21.17 years (SD = 2.65). Fifty of the participants were students from the University of Birmingham community and 74 were from the University of Edinburgh community.

4.1.2. Procedure

The experiment methodology was the same as that employed in Study 1 for both sets of participants.

4.2. Results

4.2.1. Principal component analysis

The descriptive statistics for each item in the WAI-E are displayed in Table 2. From the inter-item correlation matrix (supplied in Table 3), it was found that scores on the item 'I found it hard to concentrate when editing the wiki' correlated very weakly with the other items in the questionnaire. The item's correlation coefficient when correlated with other items was below 0.3 for 18 of the 21 correlations with other items. This item was therefore excluded from the PCA.

With the remaining 21 items, a PCA using direct oblimin rotation was conducted. The KMO measure for the analysis was high (KMO = 0.916) as was the individual item KMO values (all >0.8). Bartlett's test of sphericity for WAI-E inventory was also highly significant [$\chi^2(210) = 1565.65$, $P < 0.001$]. The results of the KMO and Bartlett's test suggest that PCA is appropriate and the correlations between items were sufficient for PCA analysis to be performed. The analysis successfully converged on three components that in combination explain

Table 2. Descriptive statistics for WAI-E items in Study 2.

Item	Item wording	*N*	Mean	SD	Min	Max
1	I felt excited when editing the wiki	124	2.61	1.00	1	5
2	I felt at ease editing the wiki	124	3.26	1.00	1	5
3	I felt comfortable about editing the wiki	124	3.39	1.03	1	5
4	I felt relaxed whilst editing the wiki	124	3.15	1.09	1	5
5	I felt apprehensive when editing the wiki	124	2.99	1.14	1	5
6	When editing the wiki, I felt anxious about making a mistake	124	3.00	1.15	1	5
7	I felt intimidated while editing the wiki	124	2.40	1.14	1	5
8	I found it hard to concentrate when editing the wiki	124	2.40	1.20	1	5
9	I felt secure when editing the wiki	124	3.47	1.02	1	5
10	I was certain I could overcome any difficulties I encountered in editing the wiki	124	3.85	0.96	1	5
11	I felt confident when contributing to the wiki	124	3.23	0.99	1	5
12	I was happy to contribute content to the wiki	124	3.80	0.89	2	5
13	I was worried about making a mistake that I could not correct when editing the wiki	124	2.06	1.11	1	5
14	I was afraid that I might do something wrong when editing the wiki	124	2.67	1.21	1	5
15	I was confident that the information I was contributing was correct	124	3.56	1.12	1	5
16	I was afraid that people would find faults with any edits I made	124	2.88	1.19	1	5
17	I was nervous of what other users might think of my edits	124	2.77	1.18	1	5
18	I was concerned that people would know it was me that was contributing to the wiki	124	1.98	1.12	1	5
19	Thoughts of being judged by other users made me feel tense	124	2.48	1.15	1	5
20	The fact that content could be changed made me uneasy	124	2.06	1.02	1	5
21	It scared me to think that I could accidentally destroy somebody else's content	124	2.31	1.20	1	5
22	I was nervous about changing existing content on the wiki	124	2.49	1.24	1	5

Table 3. Inter-item correlation matrix for WAI-E items.

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	1																					
2	0.38	1																				
3	0.41	0.72	1																			
4	0.34	0.74	0.73	1																		
5	−0.11	−0.43	−0.44	−0.56	1																	
6	−0.08	−0.38	−0.42	−0.43	0.54	1																
7	−0.17	−0.53	−0.46	−0.59	0.45	0.4	1															
8	−0.28	−0.31	−0.14	−0.29	0.13	0.14	0.35	1														
9	0.4	0.64	0.76	0.68	−0.44	−0.41	−0.5	−0.21	1													
10	0.24	0.44	0.47	0.48	−0.32	−0.36	−0.53	−0.31	0.6	1												
11	0.46	0.69	0.81	0.77	−0.54	−0.38	−0.57	−0.26	0.75	0.55	1											
12	0.56	0.55	0.6	0.58	−0.31	−0.32	−0.43	−0.25	0.62	0.43	0.61	1										
13	0.01	−0.26	−0.28	−0.26	0.3	0.41	0.34	0.16	−0.35	−0.44	−0.27	−0.24	1									
14	−0.09	−0.44	−0.43	−0.46	0.45	0.5	0.48	0.25	−0.45	−0.56	−0.48	−0.27	0.57	1								
15	0.2	0.21	0.28	0.29	−0.2	−0.05	−0.12	−0.07	0.33	0.32	0.36	0.36	−0.07	−0.12	1							
16	−0.03	−0.35	−0.43	−0.41	0.47	0.48	0.44	0.05	−0.38	−0.27	−0.37	−0.27	0.38	0.4	−0.02	1						
17	−0.12	−0.41	−0.5	−0.51	0.49	0.46	0.43	0.14	−0.43	−0.24	−0.45	−0.33	0.33	0.4	−0.08	0.62	1					
18	−0.01	−0.23	−0.23	−0.22	0.19	0.27	0.36	0.13	−0.29	−0.28	−0.23	−0.27	0.32	0.27	−0.05	0.4	0.4	1				
19	−0.1	−0.42	−0.4	−0.5	0.45	0.44	0.44	0.2	−0.36	−0.23	−0.46	−0.33	0.39	0.46	−0.05	0.62	0.65	0.44	1			
20	−0.06	−0.27	−0.28	−0.35	0.24	0.29	0.33	0.23	−0.31	−0.41	−0.26	−0.31	0.58	0.49	−0.2	0.24	0.3	0.3	0.25	1		
21	−0.01	−0.32	−0.36	−0.34	0.33	0.41	0.4	0.16	−0.46	−0.43	−0.33	−0.27	0.58	0.59	−0.02	0.44	0.41	0.42	0.43	0.52	1	
22	−0.18	−0.43	−0.48	−0.42	0.41	0.43	0.55	0.16	−0.42	−0.55	−0.45	−0.4	0.56	0.63	−0.09	0.42	0.49	0.43	0.4	0.56	0.6	1

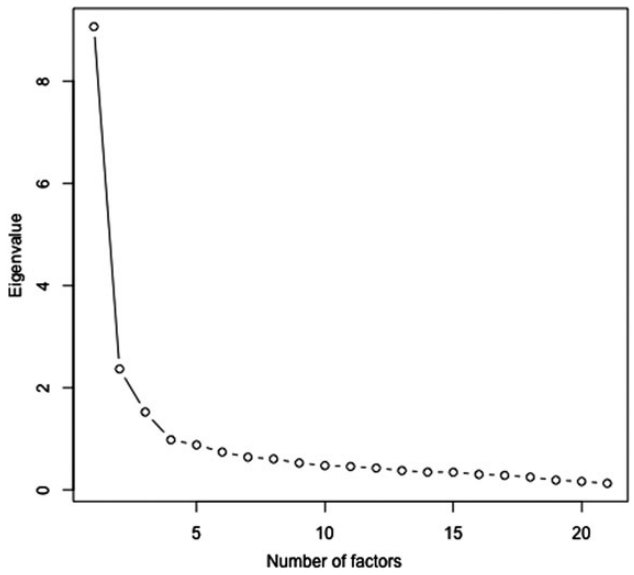

Figure 1. Scree plot for WAI-E PCA.

62% of the variance. The number of factors was chosen using the scree plot presented in Figure 1. The factor loadings after oblique rotation are presented in Table 4.

The items clustered in PC1 suggest that PC1 represents a subscale of positive affect towards wiki editing (termed positive affect). PC2 items focus on users' anxiety towards editability of the wiki (termed editability anxiety). PC3 items centre on anxiety towards contribution and peer judgement (termed contribution judgement anxiety). The items within each subscale and relevant scoring information are included in Appendix B.

4.2.2. Validity hypotheses

Considering the subscales above, to demonstrate construct validity we hypothesize that, due to it being a positive construct, participant's positive affect scores will correlate negatively with state anxiety, fear of negative evaluation, editability anxiety and contribution judgement anxiety scores.

We hypothesize that editability anxiety will correlate positively with state anxiety, fear of negative evaluation and

Table 4. Factor loadings of WAI-E items.

Item	Item wording	Positive affect (PC1)	Editability anxiety (PC2)	Contribution judgement anxiety (PC3)
11	I felt confident when contributing to the wiki	0.84		
1	I felt excited when editing the wiki	0.78		
3	I felt comfortable about editing the wiki	0.78		
12	I was happy to contribute content to the wiki	0.77		
9	I felt secure when editing the wiki	0.75		
4	I felt relaxed whilst editing the wiki	0.74		
2	I felt at ease editing the wiki	0.73		
15	I was confident that the information I was contributing was correct	0.57		
7	I felt intimidated while editing the wiki[a]	−0.37		
20	The fact that content could be changed made me uneasy		0.84	
13	I was worried about making a mistake that I could not correct when editing the wiki		0.84	
21	It scared me to think that I could accidentally destroy somebody else's content		0.73	
22	I was nervous about changing existing content on the wiki		0.69	
14	I was afraid that I might do something wrong when editing the wiki		0.66	
10[b]	I was certain I could overcome any difficulties I encountered in editing the wiki		−0.60	
18	I was concerned that people would know it was me that was contributing to the wiki[a]		0.37	
16	I was afraid that people would find faults with any edits I made			0.77
19	Thoughts of being judged by other users made me feel tense			0.75
17	I was nervous of what other users might think of my edits			0.73
5	I felt apprehensive when editing the wiki			0.51
6	When editing the wiki I felt anxious about making a mistake			0.49
	Eigenvalues	5.46	4.09	3.40
	Proportion of variance	26%	19%	16%
	Cumulative variance	26%	45%	62%

[a]Due to the relatively weak factor loading these items were not included in calculations of subscale scores.
[b]Item was reverse scored to calculate relevant subscale score.

Table 5. Descriptive statistics of variables in correlation analysis.

	Positive affect	Editability anxiety	Contribution judgement anxiety	State anxiety	Trait anxiety	FNEB
N	124	124	124	124	124	124
Number of items	8	6	5	6	20	12
Mean	26.44	13.73	14.13	10.71	37.20	36.50
SD	6.22	5.30	4.57	3.10	7.88	10.04
Scale	8–40	6–30	5–25	6–24	20–80	12–60
Min	11	6	5	6	24	14
Max	40	28	24	19	63	58

contribution anxiety. Editability anxiety will also correlate negatively with positive affect.

Finally, in terms of contribution judgement anxiety it is hypothesized that participants' scores on state anxiety, fear of negative evaluation and editability anxiety will correlate positively with contribution judgement anxiety scores. Scores on positive editing affect are hypothesized to correlate negatively with contribution judgement anxiety scores.

As Study 1 suggests that the anxiety measured by the WAI-E is state based, we hypothesize there will be no significant correlation between the subscales and trait anxiety.

4.2.3. Subscale reliability and validity results

Pearson's correlation was used to correlate the scores of the factors identified with the measures of trait and state anxiety as well as fear of negative evaluation. The scores of the items in each of the factors identified were summed to create a factor score. This score was then correlated with scores on the measures mentioned. The means and standard deviations for each measure are displayed in Table 5. The scores were also correlated with each other to identify the relationship between participants' factor scores.

Cronbach alpha reliability suggests that the positive affect subscale has high internal consistency reliability ($\alpha = 0.90$). Confirming our hypothesis, it was found that positive affect (PC1) score correlated significantly and negatively with state anxiety [$r(122) = -0.62$, $P < 0.001$], yet did not correlate significantly with trait anxiety [$r(122) = -0.06$, $P = 0.48$], suggesting that positive affect is less related to trait anxiety and more related to state. There was no significant correlation between fear of negative evaluation and the positive affect scale [$r(122) = 0.00$, $P = 0.97$]. Scores on the positive affect factor had a statistically significant and negative correlation with scores on both the editability anxiety [$r(122) = -0.52$, $P < 0.001$] and contribution judgement anxiety [$r(122) = -0.55$, $P < 0.001$] factors. Therefore, those with a more positive affect when editing held lower anxiety towards editability and concerns over judgement of contributions.

The editability anxiety scale (PC2) showed high internal consistency ($\alpha = 0.87$). There was a statistically significant and positive correlation with state anxiety [$r(122) = 0.49$, $P < 0.001$] and no statistically significant correlation with trait anxiety [$r(122) = 0.10$, $P = 0.25$]. Those with high state anxiety scores therefore also recorded high editability anxiety scores. Again this anxiety seems to be related more to state anxiety than trait anxiety. The correlation between editability anxiety and fear of negative evaluation approached significance [$r(122) = 0.17$, $P = 0.06$] although due to the number of correlations conducted and the coefficient being small, this correlation will not be interpreted. As described above, editability anxiety scores correlated significantly and negatively with positive affect. Scores on the editability and contribution judgement anxiety factors showed a positive statistically significant correlation [$r(122) = 0.60$, $P < 0.001$]. Therefore, those with high editability anxiety scores also scored highly on contribution anxiety.

The contribution judgement anxiety scale (PC3) had high internal consistency ($\alpha = 0.85$). Contribution judgement anxiety scores correlated significantly and positively with state anxiety [$r(122) = 0.60$, $P < 0.001$]. As with the other subscales, the scores on this factor did not correlate significantly with trait anxiety [$r(122) = 0.14$, $P = 0.11$]. The correlation between contribution judgement anxiety scale scores and fear of negative evaluation was positive and significant [$r(122) = 0.33$, $P < 0.001$], suggesting that those high in fear of social evaluation also recorded higher anxiety towards potential judgement of their content contributions on the wiki.

5. DISCUSSION

In sum, the work demonstrates that the WAI-E when used as a uni-dimensional scale has good reliability and validity. Yet the principal component analysis reveals a richness in the metric that is not available if using the WAI-E as a uni-dimensional construct. The clear factors identified focus on the areas of positive affect, editability and contribution judgement anxiety. These subscales have also shown high reliability and construct validity.

As mentioned in Section 1, many metrics of computer anxiety do not accurately reflect 21st Century computing with the developments in the social nature of computer use and, more specifically to wikis, the editability and flexibility of content on these social sites. The WAI-E presented in this paper seems

to accurately reflect the state anxiety measured when editing a wiki. The WAI-E includes a positive affect factor similar to previous computer anxiety measures (Loyd and Gressard, 1984; Nickell and Pinto, 1986). Crucially, it also includes items related to the social nature of wiki editing, specifically the items in the editability and contribution judgement anxiety factors. The factors of editability and contribution judgement reflect findings in the wiki literature where users have expressed concern over editing wikis due to the fact that their edits can be changed (Glaser, 2004; Lund and Smordal, 2006; Raitman *et al.*, 2005) as well as the potential judgement by other users (Guzdial *et al.*, 2002; Holtzblatt *et al.*, 2010). Indeed editability and contribution judgement concerns have been seen to be important in social technology use more widely (Grudin, 1988; Liu, 2010; Orlikowski, 1992). The judgement and editability factors are hugely relevant to the accurate measure of anxiety towards wiki interactions and make the measurement of this anxiety more accurate than existing metrics offered by the technology-related anxiety literature in these contexts.

Both the uni-dimensional scale and the subscales correlated significantly with state anxiety, suggesting that wiki anxiety is more related to the experience of anxiety at that moment in interaction, supporting previous findings on state, trait and wiki anxiety correlations (Cowan and Jack, 2010, 2011). Reflecting this, none of the factor scores correlated significantly with trait anxiety, adding support to the hypothesis that the anxiety being measured in the wiki anxiety inventory is more state focused and not significantly trait influenced. This suggests that the concepts measured by both the uni-dimensional scale and subscales may be more influenced by the situation and experience of interaction. That is not to say that the scales are merely different indicators of state anxiety. It must be remembered that state anxiety is a measurement of a general situational anxiety response, whereas items in the WAI-E are specific about the stressor. While the strong correlation between state anxiety and wiki anxiety scales suggests that the measures shared variance with state anxiety experienced (an important indicator of scale validity), the measures are not identical in their focus. The subscales also focus on different dimensions of this anxiety that, although correlated to state anxiety, may be influenced by wiki characteristics in different ways. They are therefore an important part of exploring the concept of wiki anxiety more deeply, increasing insight that the measure can give when assessing anxiety in wiki scenarios compared with using the one-factor scale.

This characterization of wiki anxiety as state based also supports the notion that it can be impacted by the design of the interaction experience, supporting previous research (Cowan and Jack 2011, 2014). We envisage the measure to be used further to assess the impact of specific design and administrative decisions on users' anxiety in editing, thus leading to causal knowledge that can be used to improve the wiki user experience. For instance, interface attributes have been developed to seek ways of improving accountability and motivate editing on wiki sites (Arazy *et al.*, 2010; Viegas *et al.*, 2004); yet, as this accountability increases, anxiety towards contribution may also increase. The WAI-E can be used to identify quantitatively what effects such interface attributes have on user anxiety. We therefore see this measure as a significant tool in researching how to develop an improved wiki user editing experience.

From the correlation analysis, fear of negative evaluation correlated significantly with contribution judgement anxiety, yet it did not, as hypothesized, correlate significantly with the other factors even though they correlated significantly with contribution judgement anxiety subscale scores. This is likely due to the fact that fear of negative evaluation as a metric is not wiki specific in its focus. The subscale items focus on wikis as the stressor, yet the fear of negative evaluation looks at the general concerns people have about being evaluated in social scenarios. We would expect this general measure to be significantly related to the contribution judgement subscale (as it has shown to be), yet fear of negative evaluation may not be expected to be highly correlated with positive editing interaction and editability anxiety, differing concepts in the wiki anxiety measure. These subscales are measuring differing elements of anxiety with wikis, one looking at positive interaction in general and the other looking at the editability of content. These may not be highly salient concepts for those who fear social evaluation. Evidence from Study 1 shows how editors' concerns over being evaluated by their peers is part of the wiki anxiety construct, yet the analysis in Study 2 suggests that this relationship with people's evaluation fears is explained by the items in the contribution and judgement subscale of the measure rather than the other scales.

We hope that the measure presented in this paper will lead to further quantitative research in the area of wiki anxiety. An important avenue is in the exploration of how wiki anxiety impacts wiki editing behaviour. A considerable amount of work in the computer anxiety domain has concentrated on the relationship between experience, use and anxiety. Studies have highlighted that those who are more computer anxious tend to have less experience or exposure to computers (Farina *et al.*, 1991; Heinssen *et al.*, 1987; Weil and Rosen, 1995), potentially due to minimization of their use by the user (Brosnan, 1998) and that anxiety can lead to avoidance (Chua *et al.*, 1999; Weil and Rosen, 1995). In a wiki context, it may be that those who experience high levels of anxiety therefore avoid contribution, potentially excluding them from wiki editing. This may impact the success of the wiki as a knowledge resource as lack of critical mass and complete group participation are important explanations for collaborative technology failures (Grudin, 1988). It may also lead to a bias in the type of individuals who contribute to public wiki sites (such as *Wikipedia*), towards those who are less anxious about contribution. Future work must look to identify the role anxiety plays in wiki editing frequency and participation. The questionnaire presented will facilitate a quantitative look at this issue.

Research is also needed on how editor roles and tasks as well as contextual factors may impact wiki editing anxiety. Previous work on co-authoring systems has highlighted the use of defined collaboration types and user permissions to support the definition of different social and functional roles in co-authoring systems (Neuwirth *et al.*, 1990). Users can take a number of different roles in the construction of knowledge through wiki sites. For instance, the task of 'gnomes' on *Wikipedia* is to conduct small-scale incremental edits to pages. Different user roles and tasks may hold different levels of anxiety when editing and, with this metric, researchers could identify the impact of user tasks on editing anxiety and the subscales identified. In addition, contextual factors such as the private (e.g. a team wiki with user login) or public (such as *Wikipedia*) nature of the site, the type and status dynamic of the audience (be it peers or a wider, more anonymous global community) may also have an effect on wiki anxiety experienced. Research has shown that users feel intimidated by the responsibility of editing in an open wiki context (Guth, 2007) and that power relationships between users who have access to wiki content have been seen to affect contribution towards wikis and ultimately wiki success (Giordano, 2007; Holtzblatt *et al.*, 2010). Relevant to this, the norm and reward structure of contribution of content to social systems are also important considerations (Orlikowski, 1992). Research could use this metric to experimentally identify the influence of role, norms and audience on aspects of this anxiety.

The metric presented, although focused on wikis as a stressor, could also be utilized as a starting point in researching issues of user experience in social and collaborative technologies more widely. The positive affect scale could be used to assess positive emotional reactions to these technologies and the editability subscale is relevant to those contribution technologies where content can be amended and edited by others. The contribution judgement anxiety factor will likely have wide applicability and relevance to other collaborative technologies such as online forum posting, online reviewing and social networking activities. Recent research on using social network status messages to gain answers to questions states that the public nature of responses is a concern for users who do not respond to these questions (Morris *et al.*, 2010). Additionally, although research has identified the main motivators of online review posting being an altruistic desire to reduce the risk of taking bad decisions for others (Jurca *et al.*, 2010) and that anxiety expressed in reviews makes them perceived to be more helpful (Yin *et al.*, to appear), similar concerns about the public nature of posting could be seen in an online review scenario. In fact, due to the increased personal association and identity attached to posts in such scenarios compared with wikis, it may be that contribution and judgement anxiety could be a more significant concern. Future studies should look to observe user anxiety within these technologies. However, caution must be taken in applying this measure with modification to wider contexts of use. The items are designed to focus specifically on wiki as the stressor so as to give measurement sensitivity in wiki contexts. Any research that looks to utilize this measure to assess the anxiety experienced by users in other social technology contexts must look to at least ensure that unique aspects of these scenarios are taken into consideration when modifying and adding scale items. Further validation of the measure to ensure that the structure and behaviour of the metric is similar across these contexts would also be advised.

It is important that readers are made aware of the limitations of the work when interpreting the findings of this research. It has to be stated that this measure was developed and tested with students who were asked to contribute content in a Higher Education context. Future research should look to replicate the findings of this research in different contexts and use scenarios as well as on wider user populations. Furthermore, although the KMO statistics and Bartlett's test suggested a robust and adequate sample for factor analysis from this data, and caution was taken to only interpret the factors using items with loadings larger than 0.4, future studies using the metric should aim to replicate the factor structure on diverse, larger samples whilst also using the current structure as the hypothesized factor structure in a confirmatory factor analysis. This would add further support for the factor stability of the metric.

Further validity testing is also needed in future research to make the validity of the factors identified more robust. The research has shown significant correlations between variables that would be expected if the uni-dimensional and subscale measures were measuring the concepts they intended to measure, making the case for construct validity. Previous research has also shown statistically significant correlations between usability measures and the uni-dimensional version of this scale used in Study 1 (Cowan and Jack, 2010). It can therefore be considered that the uni-dimensional measure is measuring a negative concept and the strength of correlation between both the subscales and the uni-dimensional version of the WAI-E suggest strongly that it is reflecting state anxiety in wiki editing. Although the correlations described in this paper and others go some way to ensure the validity of the WAI-E and its subscales as an anxiety metric, future work should attempt to identify the discriminant and predictive validity of these factors. This would bolster the evidence for validity shown in this and previous papers.

6. CONCLUSION

The work identifies the reliability and validity of the WAI-E as a tool to measure wiki anxiety in wiki editing scenarios. It identifies that its use as a uni-dimensional construct, although valid and reliable as a measure, hides the rich factor structure and fine-grained subscales that allow us to understand aspects of users' anxiety in wiki editing. These factors have shown high reliability and validity. The main contribution of this research is an inventory from which the authors hope to facilitate the measurement of what is, at present, only viewed qualitatively and is

inadequately measured in technology-related anxiety metrics. Through presenting this measure we hope to accelerate research on what are the correlates and causal factors that impact users' anxiety in wiki editing. Understanding this anxiety and how wiki site characteristics can affect this is of prime importance if we are to create a more positive, pleasurable wiki editing user experience. The authors therefore feel the measure developed will facilitate quantitative research in these important areas.

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APPENDIX A: WAI-E FOR STUDY 1

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I felt confident when contributing to the wiki (−)					
I felt excited when editing the wiki (−)					
I felt comfortable about editing the wiki (−)					
I was happy to contribute content to the wiki (−)					
I felt secure when editing the wiki (−)					
I felt relaxed whilst editing the wiki (−)					
I felt at ease editing the wiki (−)					
I was confident that the information I was contributing was correct (−)					
I felt intimidated while editing the wiki (+)					
The fact that content could be changed made me uneasy (+)					
I was worried about making a mistake that I could not correct when editing the wiki (+)					
It scared me to think that I could accidentally destroy somebody else's content (+)					
I was nervous about changing existing content on the wiki (+)					
I was afraid that I might do something wrong when editing the wiki (+)					
I was certain I could overcome any difficulties I encountered in editing the wiki (−)					
I was concerned that people would know it was me that was contributing to the wiki (+)					
I was afraid that people would find faults with any edits I made (+)					
Thoughts of being judged by other users made me feel tense (+)					
I was nervous of what other users might think of my edits (+)					
I felt apprehensive when editing the wiki (+)					
When editing the wiki I felt anxious about making a mistake (+)					
I found it hard to concentrate when editing the wiki (+)					

Those marked with (−) are reverse scored to calculate the total WAI-E score

APPENDIX B: WAI-E SUBSCALES

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Positive Affect					
I felt confident when contributing to the wiki (+)					
I felt excited when editing the wiki (+)					
I felt comfortable about editing the wiki (+)					
I was happy to contribute content to the wiki (+)					
I felt secure when editing the wiki (+)					
I felt relaxed whilst editing the wiki (+)					
I felt at ease editing the wiki (+)					
I was confident that the information I was contributing was correct (+)					
I felt intimidated while editing the wiki (−)**					
Editability Anxiety					
The fact that content could be changed made me uneasy (+)					
I was worried about making a mistake that I could not correct when editing the wiki (+)					
It scared me to think that I could accidentally destroy somebody else's content (+)					
I was nervous about changing existing content on the wiki (+)					
I was afraid that I might do something wrong when editing the wiki (+)					
I was certain I could overcome any difficulties I encountered in editing the wiki (−)					
I was concerned that people would know it was me that was contributing to the wiki (+)**					
Contribution & Judgement Anxiety					
I was afraid that people would find faults with any edits I made (+)					
Thoughts of being judged by other users made me feel tense (+)					
I was nervous of what other users might think of my edits (+)					
I felt apprehensive when editing the wiki (+)					
When editing the wiki I felt anxious about making a mistake (+)					

Those marked with (-) are reverse scored to calculate the total WAI-E score.

**Due to the relatively weak factor loading these items were not included in calculations of subscale scores.